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A ROUTE SYSTEM FOR WARGAME MODELLING (U)

by

S. SESTITO

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A ROUTE SYSTEM FOR WARGAME MODELLING

by

SABRINA SESTITO

SUMMARY

As part of a recent study using a wargame, it was necessary to model the ground movement of supplies and troops. The original algorithm endeavoured to calculate the best path given the start end the way-points. This solution was unsatisfactory, and a formal system of pre-defined routes was adopted to overcome these problems. This report outlines a method of constructing a route system for this model.

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1. INTRODUCTION.

The Aeronautical Research Laboratory (ARL) has recently been involved in an Army study using a Corps level wargame, the ARL-modified McClintic Theatre Model (MTM). The MTM was developed by the U.S. Army War College, Carlisle Barracks, Pennsylvania, U.S.A. An important part of the wargame deals with the tactical and administrative movement of units and formations. This is achieved by issueing movement orders and in the McClintic Theatre Model (MTM), the orders contained waypoints and a destination. If there is a choice of paths between two points, some indication of the required path must be specified. In the MTM, waypoints were used in order to force a vehicle to take a particular path. However, this was found to be cumbersome and confusing. To the military user, this was particularly annoying under the pressure of wargaming and it also added a sense of unreality to the game.

In practice, the Army use a route system for specifying movement operations. Routes are pre-defined paths through an area. Thus, if a route system of a type familiar to the players were to be implemented in the game, the above difficulties would disappear.

Consequently, in the process of developing the ARL-modified MTM wargame, the decision was made to implement a route system. Routes also add a sense of realism to wargames because, once a route has been constructed, the path taken by a vehicle using this route is no longer unknown to the military user.

2. METHOD OF CONSTRUCTING A ROUTE

2.1 Background information

The MTM represents terrain by a hexagonal grid system with each individual hexagon being referred to as a hex throughout this text. All movements are considered to move from the centre of one hex to the centre of another, and so on. Established roads throughout the area are defined as a sequence of the contiguous hexes that the road enters and leaves.

In order to implement routes into the system it was thus necessary to use the hexagonal grid to define a route. A route is, in basic terms, a sequence of contiguous hexes. In broader terms, though, a route is defined as a series of sectors, where a sector is either an on-road sequence of contiguous hexes, an off-road sequence of contiguous hexes, or a sequence of contiguous hexes on a pre-existing route.

The first attempt was restricted to a on-road route. Several details of the road sector had to be entered by the military user. These details included the road number, the direction of travel on the road and a waypoint, which was either a junction between two roads or the end hex of the route. By using the start hex of the route, a route made up of road sectors was constructed. This, however, was considered by the military advisers to be rather cumbersome and time-consuming.

In military practice, a route is constructed by defining a series of nodes, which are either road junctions or simply points on roads. Consequently, it was decided to use this method to construct routes. A program was written to interpret these nodes and to determine which road sectors were being referred to. From these road sectors a route could be constructed.

This program needed interactive responses from the user in order to determine which road to choose, when more than one road occurred between two nodes. In this case, the user had to enter a waypoint on the wanted road to indicate to the program which road was required.

This system provided some problems in that the user was required to refer to the map to choose between the paths. Therefore it was decided to totally eliminate the use of waypoints by displaying the various road sectors available between the two nodes, together with an arbitrary road number starting at 1. In the revised program, the user indicates which road is wanted by entering the relevant number.

The resulting system avoids ambiguity by allowing the user to specify the path to use for the movement. Furthermore, the user does not need to be familiar with the complete details of the map because the string of hexes for every alternative is displayed and only a brief reference to the map is required.

The extension of the system to include off-road sectors and sectors on pre-existing route was essentially quite easy. The off-road sector is constructed by using a method which determines the most direct path between two hexes, while the sector of a pre-existing route is obtained simply.

2.2 Essential Definitions

A route is a sequence of contiguous hexes. It is defined as a series of sectors, where a sector is either :

1. a section of an existing road,

2. a section consisting of off-road (i.e. cross-country) hexes, or

3. a section of an existing route.

Two possible methods of constructing a route will now be discussed and compared. For this, the problem of constructing a route of on-road sectors only will be considered, because the extension to the two other types is straight-forward.

2.3 Method 1

A pre-requiste to this method is that if a road exists between junction A and junction B, and the x co-ordinate of A is greater than the x co-ordinate of B, that is

$$Ax > Bx,$$

then the pair BA is stored in the database. As an example,

consider Figure 1 which contains a map with hypothetical roads where the junctions are labelled with letters. The associated stored pairs of junctions for this map would be

{ BA, BD, DA, DE, AC, AE, CE }.

Assuming we have the above information in the database, this method basically works in the following way. Suppose we wish to construct a route, from point START to point END, where START and END are coordinates in the (x,y) system. Looking at our start position, START, we can first determine that the sector BA contains this point; ie. START lies in between the sector defined by BA. The next step is then to determine whether to select the sequence of hexes between START and B, or START and A. Both alternatives are possible, but for efficiency, we will compare our current position to the final destination (i.e. the END point). We would prefer to select the sector where the endpoint of the chosen sector is closer to the END point, than the endpoint of the alternative sector. Now, because

$$| Ax - ENDx | < | Bx - ENDx |,$$

we select the sector (START A) to be the better choice at this point.

For the next sector, we therefore require that the junction A is included. Furthermore,

$$Ax < ENDx,$$

and so, we would prefer that A be in the leftmost position of

the sector pair because this would indicate that the other endpoint may be closer to the END point. From our database, we obtain the following two possibilities :

{ AC, AE }.

The sector AE contains the point END, and so this sector would be selected. Thus the final solution would be to obtain the sequence of contiguous hexes between

{ START A, A END }.

An alternative part solution to this problem (if the sector AC were chosen instead of AE) would then be

{ START A, AC }.

Comparing the last junction, i.e. C, to the END point, we see that

$C_x > END_x$.

We therefore would want to select a sector with C in position 2 (i.e. where the first junction is further left than C). From our database, there are no options (since we have already used the sector AC) and so we select those sectors where C is in the other position (i.e. in position 1). The options are

{ CE }.

Since there is only one alternative, this is chosen to be the next sector. So far, our solution is

{ START A, AC, CE }.

Comparing the last junction, i.e. E, with END, we note that

    ENDx < Ex,

and so we want a sector where E is in the second position. The only option is

    (AE)

and since this sector contains the END point, we select this as our final sector. The final solution is thus

    (START A, AC, CE, END E).

An alternative solution would also be

    (START A, AC, CE, ED, DA, A END).

It can be seen from this example that even though this method is viable, it is not practical, since an infinite number of solutions can be generated.

2.4 Method 2.

The second procedure of constructing a route uses a more practical method. The road data, when first placed into the database, were stored using the following characteristics :

1. roads are uniquely numbered;

2. roads are a string of contiguous hexes providing a unique path from beginning to end;

3. if a hex is found on two or more roads, it is a road junction, and

4. no two roads contain the same string of hexes.

This method uses the fact that each road is a unique sequence of contiguous hexes, and that e junction hex is stored on all the roads going through that junction.

2.4.1 Step 1 : two hexes specifying a road sector

An on-road sector is defined by the hexes at either end of the sector. In this discussion, hex1 is the first hex entered and is taken to be the start of the sector; hex2 is the second hex entered and is taken to be the end of the road sector.

2.4.2 Step 2 : obtaining the unique sector between two hexes

The aim here is to obtain the connecting road sector between hex1 and hex2. For this, we initially need to determine whether neither, either or both hexes are intersections between two roads. The following cases can occur :

1. Both hexes are junctions.

The corresponding roads emanating from these junctions are placed into two lists. If the same road occurs on the two lists then this road is the wanted

road. If more than one connecting road appears on these lists, extra information from the user is required to specify which of the roads is actually wanted. All the connecting road sectors between hex1 and hex2 are displayed along with an arbitrary road number. The user then chooses the road number of the wanted road sector. This provides the program with the corresponding actual road number and a unique road sector can be obtained. Thus, a unique connecting road between hex1 and hex2 can be found. Figure 2a is a graphical example.

2. The first hex is a junction, while the second hex is not.

    In this case, the roads emanating from hex1 (i.e. the junction) are obtained. From these roads, the road which contains hex2 is thus selected to be the connecting road. By definition this is unique because hex2 is not a junction and can not appear on any other road. Refer to Figure 2b for a graphical example.

3. The first hex is not a junction, while the second hex is.

    This case is similar to case 2. Here, the roads emanating from hex2 are obtained and the road which contains hex1 is selected to be the connecting road. Refer to Figure 2c.

4. Neither hex is a junction.

In this case, represented in Figure 2d, there are two distinct possibilities :

1. where the connecting road between the hexes, hex1 and hex2, can be directly obtained from the connecting road of the previously sector. Once again, by definition, this road will be unique.

2. where there is no preceding connecting road to draw upon. This is the most tedious case and occurs when the very first two hexes of the sequence of nodal hexes are not junctions. Here, the whole data-base has to be searched through and the road which contains both hexes is then determined to be the connecting road. Of course, this road will be unique and the hexes should only be found on this road.

Thus, a connecting road between hex1 and hex2 is obtained. From this connecting road, the string of contiguous hexes defining the required road sector can now be extracted. Note that if hex2 is found before hex1 in the road list then the wanted road section is reversed accordingly, so that hex2 occurs after hex1.

2.4.3 Step 3 : next road sector in sequence

The next road sector in the route can now be obtained. Hex2 now becomes hex1 for the noxt sector and hex2 for the sector is entered by the user.

The above method, commencing with determining the status of both hexes, and then determining a connecting road between the hexes is repeated and the next road sector is found and appended to the previous sectors. This process is repeated as often as required and the sequence of road sectors constitutes an on-road route.

2.5 Comparsion of the two methods

Method 1, even though it is theortically viable, it is not practical. It can produce an infinite number of solutions. On the other hand, if the sectors defined by the junction endpoints are not correctly entered a solution may never be found. Method 2, on the other hand, uses the raw data of the roads and is concerned solely with the endpoints of the entered sector and from this, directly determines the connecting road.

3. ADVANTAGE OF THE NEW ROUTE SYSTEM AND CONCLUSION

Method 2 is now implemented in the ARL-modified MTM wargame. The source is in PASCAL and was written for a VAX computer.

This procedure is better than the previous procedure because the confusion over the path which a vehicle will take by a movement order no longer exists, i.e. since the route is pre-defined. This simplifies movements and allows better planning of strategies and tactics. This method conforms with military operations where a route is marked on a map as a series of nodes.
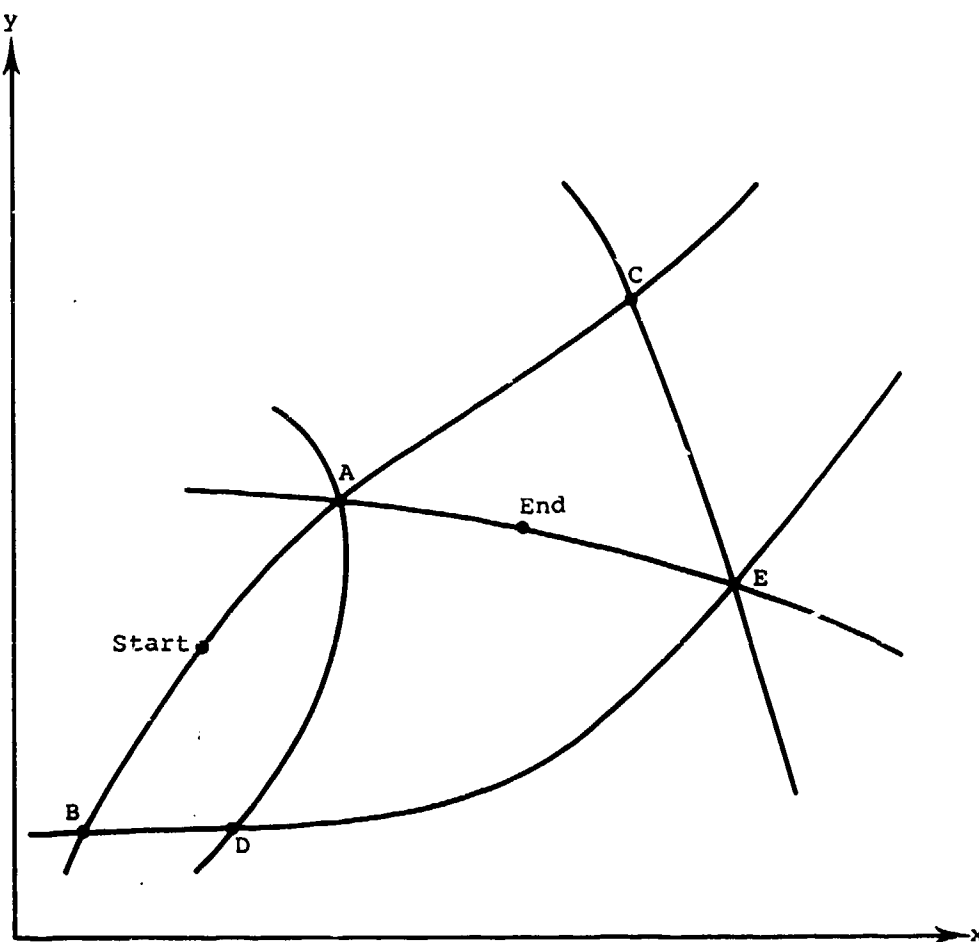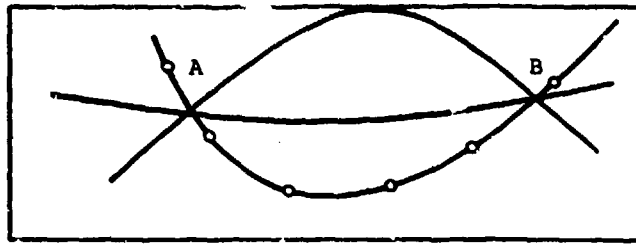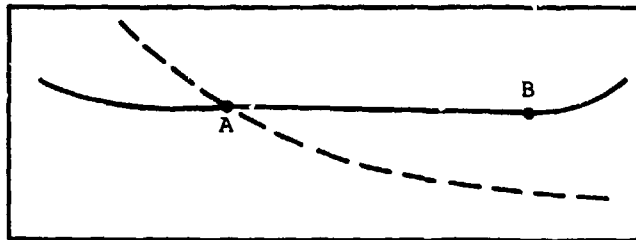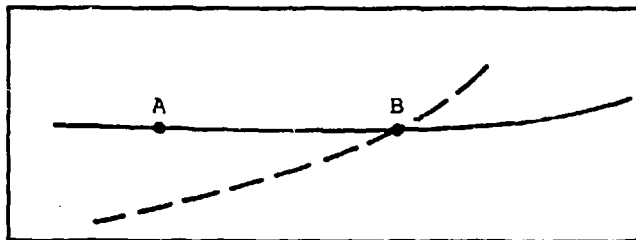
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FIG. 1.   METHOD 1 - HYPOTHETICAL AREA WITH SEVERAL
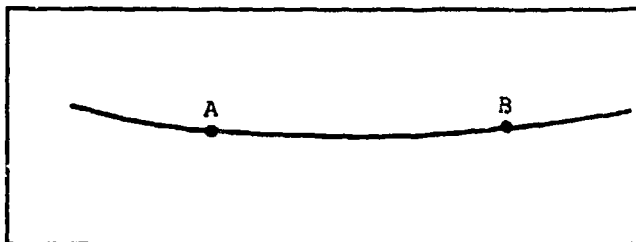ROADS JUNCTIONS

(a)   Three roads intersecting at both nodes A and B

(b)   Two roads intersecting at node A

(c)   Two roads intersecting at node B

(d)   A road with no intersections

FIG. 2.   ROAD SEGMENT BETWEEN NODE A AND NODE B

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16. ABSTRACT

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